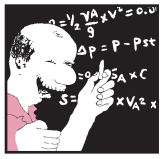
David Dellenbaugh's
SPEED&Smarts™
The newsletter of how-to tips for racing sailors Nov/Dec 2010

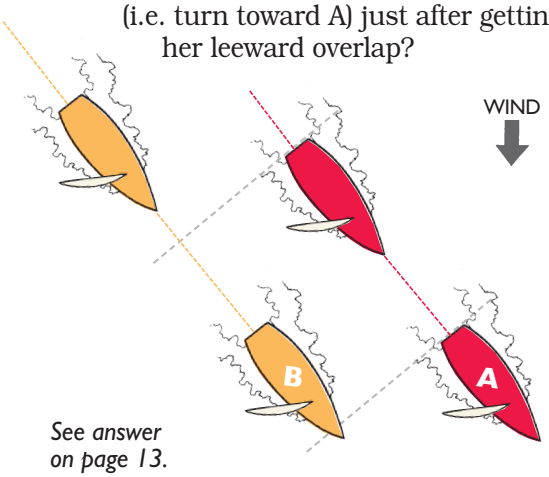


BRAIN TEASER

More rule 17

Two one-design boats are racing down the second reach of a triangular course (*see diagram*). When they started the leg, Boat A was about one hull length clear ahead of Boat B. However, B has been going faster and slowly overtakes A. Both boats hold steady courses toward the leeward mark. Half way down the leg B establishes a leeward overlap on A; at that point the boats are about one length apart.

• Are there any circumstances when it would be permissible for B to head up (i.e. turn toward A) just after getting her leeward overlap?



See answer on page 13.

ISSUE #114

Mainsail Sail Controls

Take control of your mainsail

On most boats, the mainsail is easily the biggest upwind sail and therefore has a proportionally large effect on the boat's speed and pointing performance. Because the mainsail must cover an incredible variety of wind and wave conditions, it has to be stretched and twisted into a wide range of aerodynamic shapes. Fortunately, there are quite a few sail controls to help with this.

A sail control is a device (usually a line rigged with mechanical advantage) that helps us change the sail's shape while racing. The primary controls affecting the mainsail are the mainsheet, traveler, vang, cunningham, backstay and outhaul. These systems allow us to adjust the depth of the sail, the location of that depth, the sail's twist and the angle of the sail to the wind. We can achieve a very deep and twisted light-air shape, a flat bladed-out heavy-air foil, or almost any shape in between.

But in order to get the different shapes we want, we have to know how each sail control works. When you pull on the vang, for example, what happens? And how does each control interact with the others to affect the mainsail's shape? This issue will take an in-depth look at six major mainsail controls and how each one can be used to optimize speed and pointing.

JH Peterson photo

Since two of the mainsail's three sides are supported by spars (the mast and boom), it's relatively easy to control the shape of this sail. That's a good thing because most boats have only one main, which must be manipulated so it is fast over a wide range of conditions.

IN THEORY

Visualize the shape of your main

Before we get into detail about how to change the shape of your main, let's quickly review how we look at that shape in the first place. In this issue we'll talk about how the various mainsail controls affect four basic measures of sail shape: overall depth (fullness), the position of maximum draft, the angle of attack and twist. Each of these has a large effect on the sail's total power and performance.

Depth of the sail – The depth (also called fullness or draft) of the mainsail is essentially a measure of the sail's roundness. A sail that is very curved is also quite deep. In general, depth produces power; a deeper sail is more powerful than a flatter one (but also has more drag).

Almost all the mainsail controls affect the depth of the sail. Pulling hard on the backstay flattens the sail, and the mainsheet does the same but less directly. The outhaul impacts fullness in the lower part of the sail, while the cunningham pulls draft out of the sail.

It's usually good to have a full sail in lighter air or chop and a flatter sail in moderate air (for pointing) or in heavy air (to depower).

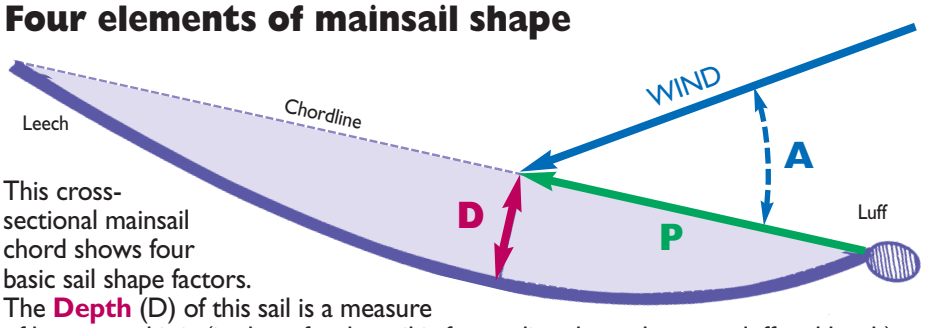
Position of maximum draft – For a mainsail, it's normally fast to position the deepest part of the sail slightly forward of the middle (i.e. a little closer to the luff than to the leech). It's easy to do this with the cunningham; more tension moves the draft forward while less tension moves it aft. Whenever you pull harder on the mainsheet or backstay, the draft moves aft, so compensate with cunningham tension.

Angle of attack – By varying the angle between the mainsail's chordline and the wind, the mainsail affects the boat's balance and directional control, much like the flaps on a plane wing. Trimming the mainsheet initially brings the main in and changes the angle of attack, but the traveler ultimately controls the angle of attack while sailing upwind. A wider angle of attack produces more power (and drag).

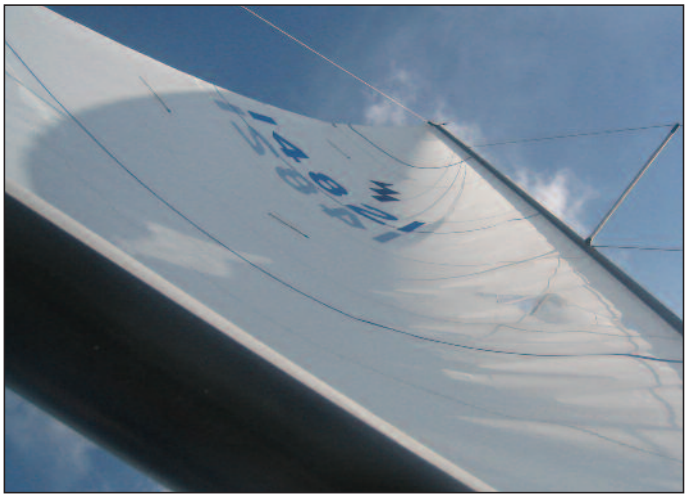
Twist – Twist is the difference in angle of attack as you go from the bottom to the top of the mainsail. Every sail has at least some twist – the ideal amount varies by wind, waves and other conditions.

The two sail controls that have by far the largest impact on mainsail twist are the mainsheet and vang (which exists primarily to reduce twist). Both pull down on the boom, which affects leech tension and therefore twist. In general, less twist produces more power.

Four elements of mainsail shape



This cross-sectional mainsail chord shows four basic sail shape factors. The **Depth** (D) of this sail is a measure of how round it is (i.e. how far the sail is from a line drawn between luff and leech). The **Position of maximum draft** (P) is determined by how far aft the deepest part of the sail is from the luff. The **Angle of attack** (A) is the angle at which the wind hits the sail. The sail's **Twist** (T, below) is a measure of the change in angle of attack as you go higher up the mainsail.



Photos courtesy North Sails

The purpose of having sail controls is so you can change the shape of the mainsail to match the existing wind and wave conditions. On most boats, one all-purpose main has to morph from a deep light-air shape (left) to a flat shape for heavier wind (right). The addition of draft stripes on this sail makes it easier for sailors onboard to see the overall depth and the position of maximum draft.

Mainsail Sail Controls

There are many ways to fine-tune the shape of your mainsail. By using all of these controls in concert, you can constantly tweak the sail to maintain optimal shape in changing conditions.

Halyard (H)
Controls luff tension (and draft position) in the top part of the sail.

Cunningham (C)
Controls luff tension in the lower part of the sail and affects depth and draft position, especially in the bottom half of the sail.

Note: There are many tuning controls that also have a large impact on mainsail shape (e.g. rake, prebend, rig tension), and these will be the subject of a future issue.

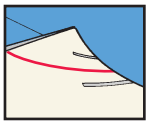
Backstay (B)
Bends the mast and thereby affects depth and draft position in the main (as well as headstay sag and depth and draft position in the jib).

Boom vang (V)
Pulls down on the boom and puts more tension on the leech of the main, which reduces twist, bends the mast and flattens the sail. Depending on how the vang is rigged, it may also impact headstay tension and lower mast bend.

Outhaul (O)
Controls tension along the foot of the sail which affects the amount of draft in the lower third of the main and the amount of 'return' (windward 'hook') in the lower part of the leech and the lower batten.

Mainsheet (M)
Pulls the boom down and in, which affects mast bend, twist, sail depth and draft position.

Traveler (T)
Controls the athwartships position of the boom and thereby the angle of attack of the entire sail.



MAINSHEET

The most critical sail control

The mainsheet is such an important tool because it affects mainsail shape in so many ways. When you pull harder on the sheet it generally does the following:

• Brings the boom closer to centerline, which increases the sail's angle of attack and adds power.

• Exerts a downward force on the boom, which reduces twist in the leech and adds power.

• Pulls aft on the tip of the mast, which bends the mast and makes the sail flatter overall (because it pulls the center of the luff away from the leech), reducing power. Mast bend also moves the draft aft in the sail.

• Makes the headstay tighter, which flattens the jib, improves pointing and reduces power.

Because of all this, playing the sheet is a critical part of changing gears. When you get a puff, lull, wave or flat spot, the first thing you should usually do is adjust the sheet. That's why it is a good idea to have the helmsperson play the sheet if possible (because he or she can feel the boat through the helm) and to have the main trimmer keep the sheet in his or her hands (rather than cleat it).

JH Peterson photo

The mainsheet is the primary control for adjusting the amount of twist in the mainsail. Tension the sheet to get a tighter leech and less twist; ease the sheet to loosen the leech and add twist. In this photo, Boat A has the least twist; Boat B has more (possibly because she is in disturbed air); and Boat C has the most twist (too much for a boat sailing in moderate breeze, especially when trying to avoid falling into the bad air of boats ahead).

My philosophy about the mainsheet is that I always try to trim it harder. This, of course, depends a lot on feel. If the boat feels good (pressured up and going fast through the water), then I trim harder. If the boat starts to feel not so good (slowing down, straightening up), I ease the sheet a little to get the boat going. Then I try trimming harder again and the cycle repeats itself.

If you trim in and this makes the boat feel better (more lively, more heel, but not overpowered), then you probably did the right thing and you can try trimming even more. But if you trim harder and the boat feels worse (more mushy and less lively), then you may have gone too far.

The mainsheet is a critical control and has a big impact on sail shape, but it doesn't operate alone in a vacuum. As you will see in the rest of this issue, the sheet interacts and overlaps with a number of other controls such as the traveler, vang and backstay.

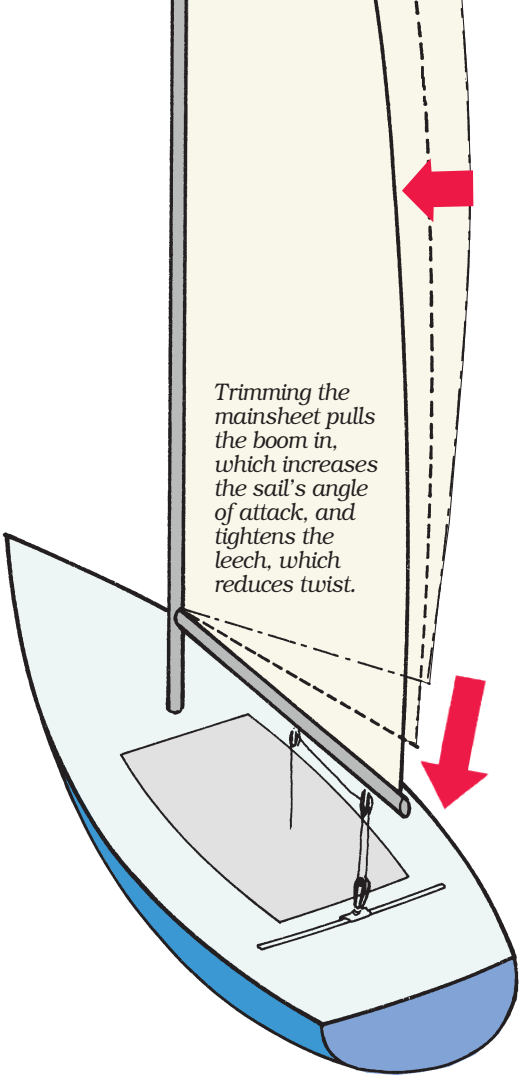
Mainsheet trimming guides

When trimming the main, perhaps the most important consideration is how hard to trim the sheet. In other words, how much twist do you want in the sail? It's hard to quantify twist, so here are some rules of thumb that will keep you in the ballpark:

Use the angle of the top batten – A good starting point is to trim your mainsheet until the top batten is roughly parallel to the boom. This is a good all-around twist setting. In light air and/or chop, ease the sheet so the top batten falls off slightly to leeward. In moderate air and flat water, you can trim the sheet hard enough so the top batten actually angles slightly to windward. In heavy air when you are overpowered, the top batten will fall off a bit to leeward again.

Watch the top batten telltale – The action of the telltale on the leech at the end of the top batten is another good clue for proper twist. In light air, ease the sheet just enough so the telltale is flowing aft almost all of the time. In ideal pointing conditions (moderate air and flat water), try trimming the sheet hard enough so the telltale is stalling (curled around behind the sail) at least 50% of the time.

Put a reference mark on the sheet – Here is a simple guideline: Trim your main for going upwind and then put a piece of colored tape around the sheet near the block on the boom. Now monitor how well you are going in the race – when the boat feels good and you are fast compared to nearby boats, note where the tape is. Use this guide to reproduce fast sheet trim.



Other tips and notes

• **Don't cleat the sheet**. The wind and wave conditions are different all the time (even when it seems like they are static), so if you want to keep going fast you have to adjust your mainsail trim continually. Try never to put the mainsheet in its cleat; if you do, you will be much less likely to make adjustments when conditions change.

• **Use as few parts in the mainsheet as possible**. If your class permits, try taking one part (or even two parts) out of your mainsheet in light air. Though this makes it harder to trim the main, it gives you a much better feel for pressure on the sail and lets you ease the main much more easily (which is especially important downwind).

• **Ease for speed, trim for height**. When trimming the mainsail, it's important to observe your performance relative to nearby boats. If you are going slower than they are, try easing the sheet a little. If your speed is good but pointing is a problem, try trimming slightly harder.

• **Use vang and traveler**. In breeze, it may be difficult to get the right mainsail shape with just mainsheet (and it's hard to play the sheet). That's why you should adjust the vang and traveler in concert with the sheet. The vang helps pull the boom down (*see pages 8-9*), while the traveler makes it easier to change the sail's angle of attack (*pages 6-7*).

• **Is backwinding OK?** When it's breezy, some backwinding of the main along the luff (mast) is normal and won't hurt your speed. But if this gets to be more than just a subtle bubble, you may have to trim the sheet a little harder to flatten the sail and open the slot.

• **Downwind trim.** In general you should ease the mainsheet until you see slight backwind along the front of the sail, then trim it in a little.

◀ *Pulling on the sheet brings the sail in toward the middle of the boat at first, which increases the sail's overall 'angle of attack.' Once the sail is trimmed near the middle, more mainsheet tension pulls the boom primarily down. This tightens the leech between head and clew, reducing twist and increasing the angle of attack at the top of the main.*

Watch for 'overbend' wrinkles

One thing that happens when you trim the mainsheet is that you also bend the mast. The force on the sheet transfers into the mainsail leech, pulling the top of the mast aft and flexing the middle of the mast forward.

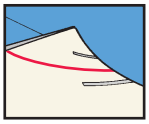
As the mast bends, the mainsail gets flatter. This is generally a good thing because when you trim the mainsheet harder you probably have more wind and therefore need a flatter sail. Many smaller boats don't have backstays, so trimming the sheet is their best way to bend the mast and flatten the main.

However, it is possible to have too much of a good thing. If you keep pulling the mainsheet harder, you continue bending the mast. When the bend of the mast surpasses the designed luff curve of the sail, you will start to see "overbend" or "inversion" wrinkles in the lower part of the main, angling from the clew toward the luff.

Having a hint of these wrinkles is OK because it tells you that your sail has reached the point of maximum designed flatness. But when the wrinkles get ugly and run all the way from the clew to the mast, you lose valuable power and the ability to point. The lower leech of the main may actually hinge to leeward, destroying the fast mainsail shape. In this case, a simple ease of the sheet is often enough to solve the problem (though sometimes you also need to adjust backstay, vang or other tuning controls).

JH Peterson photo

Boat 2074 probably has too many 'overbend' wrinkles running from the clew up toward the middle of the sail's luff. These are caused by excessive mast bend, which is often a result of over-zealous backstay pulling. Since these MC Scows don't have backstays, in this case 2074 probably has too much mainsheet tension. Easing the sheet slightly will eliminate all but a hint of wrinkles, giving the sail better shape for speed and a firmer leech for pointing.



TRAVELER

Adjusting the angle of attack

While the mainsheet helps you get the right amount of twist in the mainsail, the traveler allows you to move the entire sail from side to side so you can fine-tune its angle of attack (the angle of the sail to the wind). The traveler therefore has a large effect on your boat's directional tendency (pointing or footing), helm balance (windward or leeward helm) and overall speed.

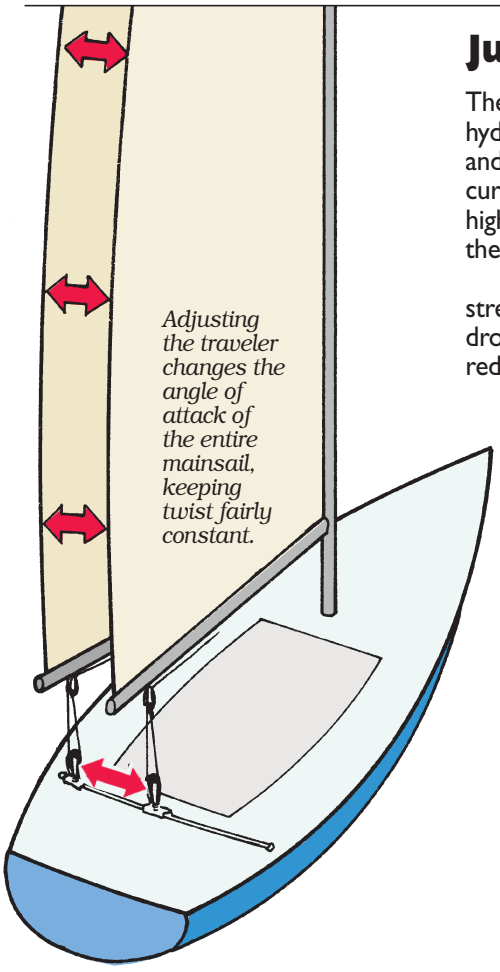
By moving the traveler to windward, you increase the mainsail's angle of attack. This adds power to the sailplan because the wind hits the sail at an angle that is closer to perpendicular. It also increases windward helm (because there is more force pushing sideways on the mainsail leech) and makes the boat want to point higher. By moving the traveler to leeward, you decrease the angle of attack, reduce power and make it easier to sail the boat fast forward.

The traveler works in concert with the mainsheet to get the right trim. The key thing is not where your traveler car ends up, but where the boom (and therefore the entire sail) is located. The basic trimming process is to adjust the mainsheet until you have the right amount of twist for the wind and wave conditions – then move the traveler to position the boom.

In light air, trim the sheet until the top batten is slightly twisted open and the top batten telltale is flowing most of the time. Then pull the traveler to windward until the boom is at least up to centerline. Some boats actually go faster with the boom slightly above the middle of the boat. This generates more power which is good in light air, but be careful because increasing the sail's angle of attack will also increase the chances of having too much drag and stalling.

In moderate air and flat water, trim the sheet with much less twist so the top batten is angled slightly to windward and the top batten telltale is stalled about 50% of the time. Then position the traveler so the boom is roughly on centerline.

In heavy air, ease the sheet until the top batten is slightly open again. Then drop the traveler (and decrease the angle of attack) until you have just the right amount of windward helm and heel without too much power. If you are sailing in puffy conditions, change gears with the traveler to make the sail powerful in the lulls (boom near centerline) and depowered in the puffs (boom to leeward of middle).

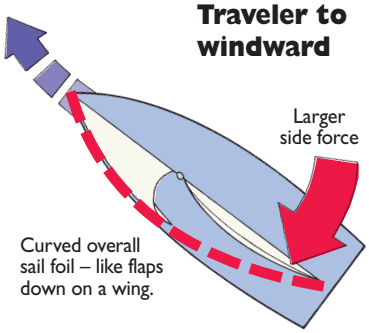


Adjusting the traveler changes the angle of attack of the entire mainsail, keeping twist fairly constant.

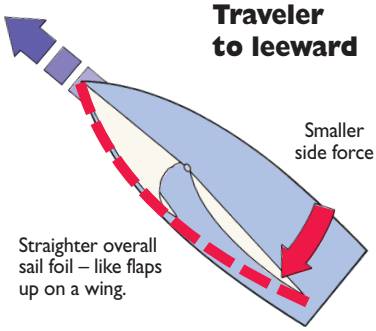
Just like flaps on an airplane wing

The traveler controls the angle of attack of the mainsail in much the same way as hydraulic cylinders control the flaps on an airplane wing. When the plane is going slowly and needs a lot of lift (e.g. to take off or land), the flaps go down to make the wing more curved and more angled to the oncoming wind. Similarly, when a boat needs to point higher, the traveler goes to windward so the sail is in the middle of the boat. This makes the entire sail plan more curved and generates lift and helm.

When the plane wants to go fast, the flaps are retracted to make the wing more streamlined and reduce drag. A boat is the same. When speed is the goal, the traveler drops down so the mainsail is more in line with the headsail. This minimizes drag and reduces windward helm so the boat can go faster forward.



When the traveler is pulled to windward so the boom is near centerline, the leech of the sail 'kicks' the air flow to windward, creating a large side force to leeward at the stern. This creates windward helm and makes the bow turn to windward.



When the traveler is eased to leeward, the mainsail leech is more open. This allows the air to flow more easily off the back of the sail. As a result there is less sideways force on the stern of the boat, and the driver feels less windward helm.

On almost every boat, it's best to carry the boom near the centerline of the boat when sailing upwind. This provides an optimal combination of speed and pointing. In order to get the boom on centerline, you have to position the traveler car to windward. If you leave the traveler in the middle, it will be impossible to trim the mainsheet hard enough to get the boom on centerline – and if you try to do this you will end up with way too much leech tension.

The goal is to use the mainsheet and traveler in concert to position the boom near centerline and have the right amount of sheet tension (twist) at the same time. In light air and/or chop you can't trim the sheet very hard, so the traveler has to be all the way to windward. As the wind increases and you can sheet harder, the traveler doesn't have to be so high to keep the boom centered.

On some boats like this Sonar, it is actually fast to sail upwind with the boom *above* centerline until you start to get overpowered. JH Peterson photo

Other tips and notes

• **Use reference marks.** Place a number scale on your traveler track or use existing reference points (e.g. the edge of the seat). This helps you know where to set the traveler car in various conditions. For example, when it's light and choppy, it may be fast to set the traveler at position #1, or near the end of the track.

• **No traveler?** If your boat is not rigged with a traveler, you have to use vang and mainsheet to get the boom in the right position. Boats without travelers often use some type of bridle arrangement to keep the boom in the middle of the boat upwind, and they use vang sheeting (lots of vang) to maintain leech tension when it's windy.

• **Downwind trim.** The traveler position is not too critical off the wind because then you can control twist with vang tension and angle of attack with mainsheet. It often helps to drop the traveler to leeward on an overpowered reach, or on a run if this is necessary to ease the main all the way out. But don't forget to pre-set the traveler at its upwind position before you drop your chute at the leeward mark.

Play traveler or mainsheet?

When you're sailing upwind and you get an overpowering puff, it's not always clear how to depower. Should you ease the mainsheet so the mainsail twists more and spills power primarily from the upper part of the sail? Or should you keep the mainsheet tight and drop the traveler instead, reducing the sail's angle of attack and therefore the power it produces?

Here are some factors to consider when thinking about how to do this:

Sea state – When you are sailing in bumpy water, the entire mainsail moves around a lot relative to the wind. In these conditions, it's critical to be able to adjust the amount of twist in the sail, so play the mainsheet. This gives you a better chance that at least some part of the main will be at the right angle of attack each moment. When the water is flat, it's OK to sail with less twist and less adjustment of twist, so it often works well to play the traveler.

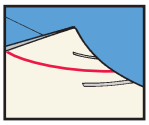
Boat type – Lighter, faster boats (e.g. skiffs and multihulls) tend to perform better when they trim the main with a wider range of twist, so they rely primarily on mainsheet. Heavier, slower boats typically sail with less twist, and they don't change the amount of twist as much, so they can use the traveler more.

Sail design – Mains with big roaches (typically with full-length battens at the top) are very sensitive to small changes in twist, so it's important to play the mainsheet to change gears and keep the boat going fast. Traditional sails with less roach are more suited for playing the traveler.

Traveler system – Sometimes the choice of how to trim the main is dictated by the layout of your boat. Is it easier to play the mainsheet or traveler? Is it physically possible for the helmsperson to adjust both quickly? Is there another crewmember who can play either one or both?

Wind conditions – Occasionally the technique of trimming the main needs to be changed to fit the wind. You may normally drop the traveler to depower the boat in puffs, but if you have a day when the puffs are much stronger than the lulls, will you be able to depower the boat enough using just the traveler? Sometimes you need to play the mainsheet instead, or in addition.

Personal preference – In the end, the technique you choose for trimming the main and adjusting its shape depends a lot on what makes you comfortable and what you have found to work best in the past. My personal preference in most boats is to play the sheet as much as possible. I adjust the traveler for upcoming trends in the wind velocity and then use the sheet for small, quick changes.



BOOM VANG

Control twist in the main

The primary job of the boom vang (or 'kicker' in some places) is to limit the amount of mainsail twist. The vang does this by pulling down on the boom and straightening the leech, which reduces twist.

Twist is a change (a decrease) in the mainsail's angle of attack as you go from the bottom to the top of the sail. If you decrease twist, you increase the angle of attack of the sail, especially in the top sections. This adds power and helm.

The vang is a valuable tool in moderate to heavy wind. In light air, you often want more twist in the sail (not less), so putting any tension on the vang would be slow, both upwind and downwind. Once the breeze increases enough that you need more leech tension (for pointing) and a flatter main, start pulling on the vang.

When there is enough wind that you are fully hiked and still need to depower, the vang becomes critical. With a lot of vang tension it's easier to play the sheet and to change the sail's angle of attack (which controls power and windward helm). The key thing about using vang is that when you ease the sail to leeward you can maintain leech tension. This is very important for keeping mast bend, a tight forestay and a flat mainsail.

While the vang reduces twist in the sail, it also has other effects (*see above right*). Tensioning the vang pulls the mast tip aft which bends the mast. It also pushes the boom into the mast causing lower mast bend, and, on some boats, bends the boom. All of these things make the mainsail flatter, which is good when you are overpowered.

It's easy, however, to have too much vang. How will you recognize this? Upwind you will see a tight leech, often hooking to windward, plus you may get overbend wrinkles running from the lower mast toward the clew. Downwind too much vang makes the top batten angle to windward (beyond parallel to the boom).

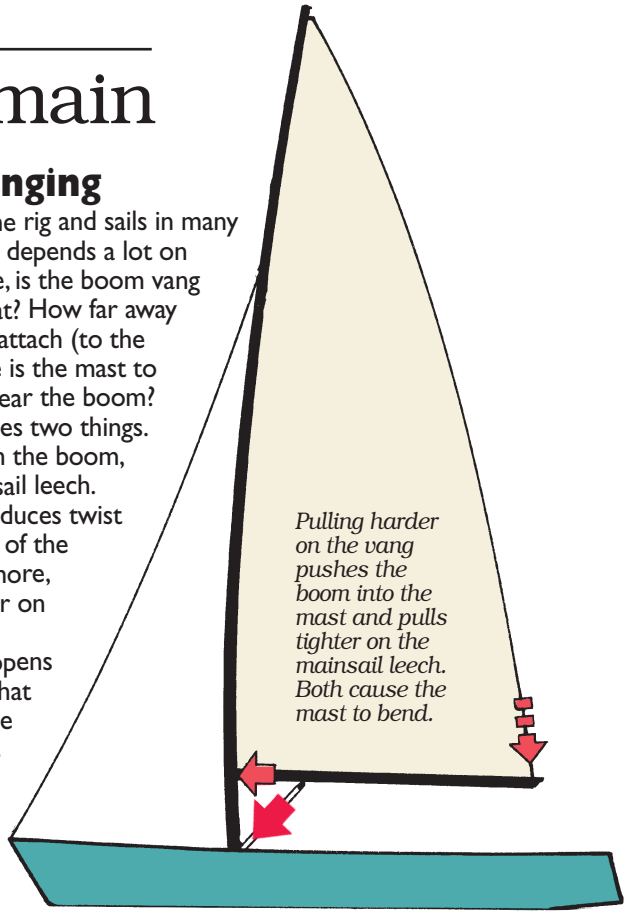
The mechanics of vanging

Pulling harder on the vang affects the rig and sails in many different ways, but the exact impact depends a lot on how the boat is rigged. For example, is the boom vang anchored to the mast or to the boat? How far away from the gooseneck does the vang attach (to the boom and mast or boat)? How free is the mast to bend forward in its lower section near the boom?

In general, pulling on the vang does two things. First, it exerts a downward force on the boom, which mostly transfers to the mainsail leech. This force tightens the leech and reduces twist in the sail. It also pulls aft on the tip of the mast, which makes the mast bend more, flattens the mainsail and pulls harder on the headstay, reducing headstay sag.

The second major thing that happens when you pull hard on the vang is that it pushes the boom forward into the mast (at the gooseneck). This bends the bottom part of the mast and flattens the lower part of the sail.

Pulling harder on the vang also might bend the boom (and thereby flatten the sail).



As with all sail controls, it's very helpful to use reference marks on the vang. The normal way is to mark two parts of the vang system – one mark should be on the 'standing' part that doesn't move (e.g. on the strut in this photo) while the other is on an adjacent moveable part of line (or you can use a point such as the top of the triple block above). Unlike other controls that can be calibrated in absolute terms (e.g. mast rake), your vang calibrations are relative (*see page 16*), so you can use the marks only for comparison to your own previous vang settings. For example, if you are at the green mark while sailing fast upwind on the first beat, you should use that mark again for the second beat (unless there is a change in the wind). JH Peterson photo

Other tips and notes

• **Some vangs push up!** Beware of spring-loaded vangs that support the weight of the boom. In light air they actually push the boom up, so you may have to pull harder on the vang than you think to get the right amount of leech tension.

• **Remove vang slack.** Even if the wind is light and you're not using any vang (because that would make the leech too tight), it often helps to pull the slack out of the line used for the vang system. This gets the vang more out of the way of forward crew members, making it easier for them to cross the boat in tacks.

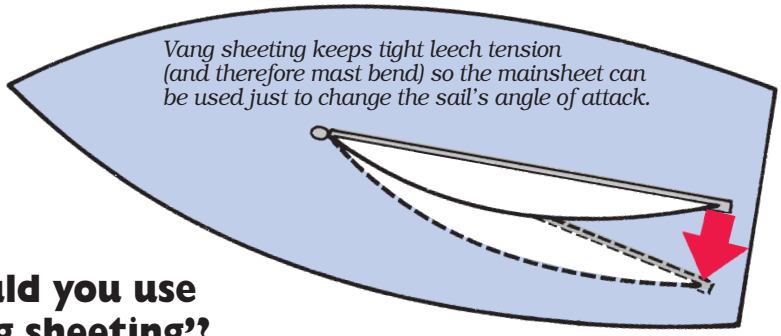
• **Play the vang.** Since the wind is always changing, one of the keys to going fast upwind is 'shifting gears' (i.e. constantly adjusting your sail settings to match changes in wind and waves). This applies to the vang just like any other control. If you are using the vang to control leech tension, you have to play the vang for wind velocity – ease it in lulls and pull more tension in puffs.

There are other times when you need to play the vang. When you bear off in breeze (e.g. around the windward mark), ease the vang to release tension on the main leech. If you are sailing on a windy reach, ease when you are overpowered in a puff and pull the vang back on to add power when the puff passes.

• **Downwind trim.** On reaches and runs the traveler and sheet are used for angle of attack, and the vang controls twist. You typically need less vang downwind than upwind, so you have to ease it while or after rounding the windward mark.

A good rule of thumb is to set the vang so the top batten is parallel to the boom (just as you would do upwind). You may want more twist than this (a more eased vang) in light air or on boats where the boom can't go out all the way because of the shrouds (twist allows the top of the sail to rotate so it is more perpendicular to the wind).

You may want less twist than this (a tighter vang) when it's windy and you are trying to keep the boat under control (a twisted top leech causes the boat to rock side to side).



Should you use 'vang sheeting'?

In the normal upwind trimming mode, you use the mainsheet primarily to control twist (the up-and-down movement of the boom) and the traveler to control the sail's angle of attack (the in-and-out boom movement). The vang does not play a major part in this scenario. There is, however, another trimming style that works effectively on some boats in windy conditions.

'Vang sheeting' is a technique that uses a very tight vang upwind in breeze. The vang handles twist (the up-and-down control of the boom previously achieved with the mainsheet), and the mainsheet adjusts the sail's angle of attack (the in-and-out trim of the boom previously controlled by the traveler). When you 'vang sheet,' you tension the vang to get about the right amount of twist in the mainsail; then you play the sheet to keep the boat on its feet and going fast in the puffs and shifts.

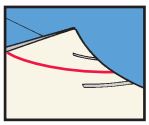
Vang sheeting is especially effective on smaller and lighter boats that must use the vang to get enough mast bend and headstay tension. These include boats, such as 470s, that don't have backstays and/or travelers but do have powerful vangs that are easy to adjust while racing. When it's windy, these boats need lots of vang tension to keep the headstay straight, the mast bent and the sails flat.

Vang sheeting is also a good idea when you're on a boat where it's hard to play the traveler efficiently, or when the puffs are so big that simply dumping the traveler may not depower the boat enough. Having vang tension upwind makes it much easier to play the mainsheet, no matter which trimming technique you use.

JH Peterson photo

These two Flying Scots are racing upwind in moderate breeze without any vang tension (note the slack vang systems). Since the Scot mast is very stiff and stepped on deck, pulling on the vang doesn't bend the lower part of the mast much and therefore isn't very helpful for flattening that section of the main. However, there are other reasons to pull hard on the vang, especially when there's enough wind so the boat starts to get overpowered.

The primary benefit of tensioning the vang is to get more mainsail leech tension. When the boat doesn't have a backstay, this is the best way to: 1) keep the forestay tighter, which flattens the jib and helps pointing; and 2) bend the mast (at least a little) to help flatten the mainsail. The Scot vang is very effective in getting leech tension because it is rigged in such a way that it has a lot of leverage on the boom (and therefore on the leech).



CUNNINGHAM

Re-position the mainsail's draft

Contrary to the belief of many less-experienced racers, the purpose of the cunningham is not to get rid of wrinkles that often exist along the luff of the mainsail. The real reason that most mainsails have a cunningham is so we can adjust the position of draft in the sail and get the right overall sail shape. This is much more critical than simply having a smooth sail.

Even though wrinkles may look bad, they are usually not slow. In fact, many sailors use the term "speed wrinkles" to describe the small wrinkles that you often see along the luff of a mainsail in light air. Sometimes you can't get the optimal shape without wrinkles. For example, in light air pulling hard enough on the cunningham to remove wrinkles usually makes the sail too flat and draft-forward.

Before adjusting the cunningham, use other controls to set the overall shape of the mainsail. For example, trim the mainsheet (and pull the backstay if necessary) to get the right amount of mast bend, depth and twist. Then tension the cunningham to re-position the area of maximum draft.

In most wind conditions, your goal should be to get the maximum draft about 45% aft of the luff (just slightly forward of the sail's middle). In light air with little mast bend, you may not need to pull the cunningham at all to get the draft in the right place. But as the wind gets stronger and the mast bends, the draft moves aft, so you need more and more cunningham to pull the draft forward to its original position.

When it's windy, pull hard on the cunningham to keep the draft forward, flatten the sail and help open the leech. At this point, all 'speed wrinkles' are long gone and you will have a smooth luff with quite a bit of vertical tension. Don't forget to ease the cunningham when you get a lull or go downwind.

JH Peterson photo

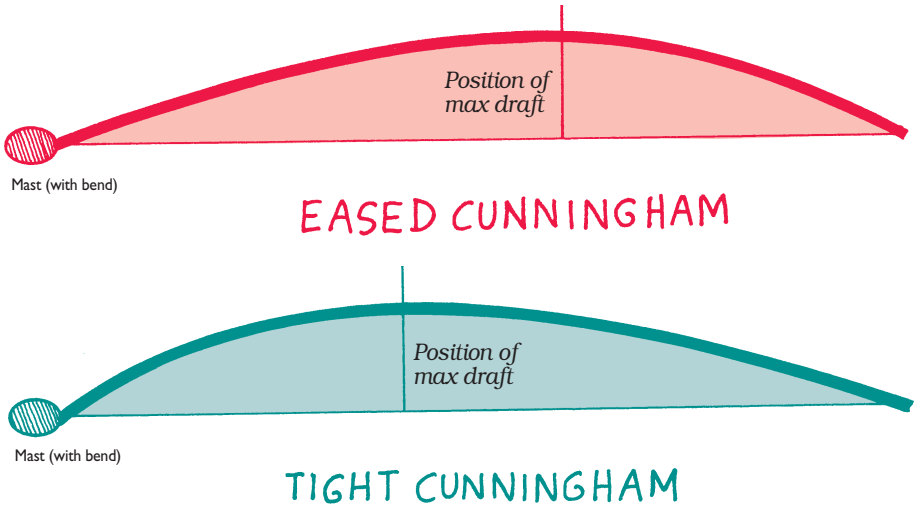
Luff tension examples

Here are two boats with very different theories about luff tension. Boat A has lots of cunningham while Boat B has lots of luff wrinkles. Which is better?

In this race the water looks fairly flat and the wind is moderate (the crews are hiking but not overpowered). Therefore they can trim the mainsheet pretty hard. This will bend the mast, flatten the sail and move the draft aft, so they probably need at least a little cunningham to keep the draft forward. At the same time, they don't want so much cunningham that they over-flatten and depower the main.

It looks like Boat A has gone a little too far with cunningham. They've pulled it so hard that there is a big wrinkle of extra fabric at the tack of the sail. This makes the mainsail quite flat, and it looks (though it's hard to be sure) that the draft is a little too far forward. It would probably be faster for A to ease the cunningham until there is at least a hint of horizontal wrinkles along the mast.

Boat B, on the other hand, is at the opposite end of the luff-tension spectrum. The draft in this mainsail is way far back in the sail, which is not fast. In addition, the extreme wrinkles indicate other possible problems such as too much mast bend. In this case you can see that this main is not fully hoisted. The crew should pull the halyard all the way up and then tension the cunningham so there are just slight luff wrinkles.



After you bend the mast with mainsheet, backstay or vang, the cunningham is a critical control for re-positioning the draft in the sail. When the middle of the mast bows forward, it pulls fabric with it from the middle of the sail. As a result, the front half of the sail becomes flatter and the position of maximum depth moves aft. Without cunningham tension, the draft will end up farther aft than 50% (top drawing), which is not fast when you have conditions that warrant bending the mast.

The optimal location for maximum draft in a mainsail is usually around 45% from the forward edge of the sail. To maintain this draft position when you bend the mast, you have to pull on the cunningham (bottom drawing). The more the mast bends, the harder you have to pull (and the more likely you will remove all the light-air 'speed' wrinkles). Mast bend and cunningham tension both flatten the mainsail, so it makes sense for them to work together as the wind increases. However, their combined effect makes it possible to flatten the main too much.

Other tips and notes

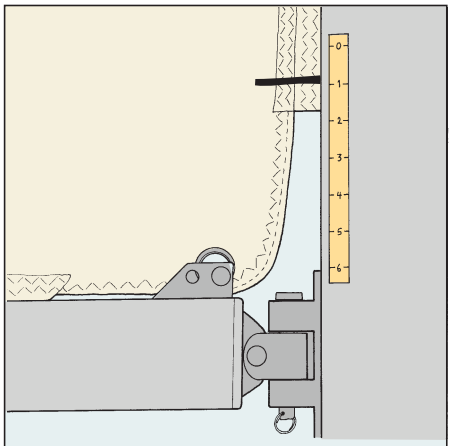
• **Older sails need more luff tension.** Most mainsails stretch (or shrink) as they get older and lose their fast designed shape. The sails typically become deeper, and the position of maximum draft moves aft (toward the leech). To compensate for this, you typically need to pull a little harder on the cunningham than you would for a newer sail. This additional luff tension takes some fullness out of the sail and helps move the draft forward toward its original position. With older sails you will seldom end up with the 'speed wrinkles' that you see in newer sails.

• **Don't forget the halyard.** There are two ways to adjust mainsail luff tension – cunningham and halyard. Sometimes the main halyard is locked in one position, but on other boats it's adjustable and has a large effect on mainsail shape. In light air, if you pull the halyard all the way up you may have too much luff tension, even if the cunningham is completely eased. I usually set the main halyard so the luff tension is perfect downwind; then I use cunningham if necessary to get more luff tension upwind.

• **Cunningham downwind.** When you're sailing downwind, you generally need less luff tension than sailing upwind. That's because the mast gets a lot straighter on runs, and it's all right if the draft is a little farther aft than 45%.

In addition, the sail should usually be fuller downwind, so you don't want the flattening effects that you get with more luff tension. One exception is when you're on an overpowered reach; in that case, it's good to maintain lots of cunningham to depower the mainsail.

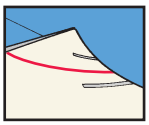
The cunningham got its name from Briggs Cunningham, who was the helmsman on the 12-Meter Columbia during her successful defense of the America's Cup in 1958.



Measure the 'ham'

Because every mainsail shrinks or stretches differently and halyard height is variable, it's difficult to measure mainsail luff tension in an absolute sense (i.e. in a way that you can compare it to other boats in your class). However, it's easy to gauge relative cunningham tension, and this is important for being able to reproduce fast settings.

The best system is to use a simple number scale that runs vertically on the mast near the gooseneck and a bold mark on the main luff (*see above*). Before each race, find the number that gives you optimal cunningham settings both upwind and downwind – then you can make quick adjustments as you begin each leg.



BACKSTAY

Regulate power with mast bend

The backstay is a powerful tool that gives you control over mast bend. The harder you pull on the backstay, the more you bend the mast. As the mast becomes more curved, the mainsail gets flatter, the position of maximum draft moves aft and the main leech twists more. Therefore, one rule of thumb is that whenever you adjust the backstay you almost always have to change other controls as well. For example, you may need more cunningham to keep the draft forward and more sheet to maintain the desired twist.

Since bending the mast reduces the power in the mainsail, the backstay is used primarily when you have enough wind that you need flatter sails to point higher or to start depowering. It is very seldom that you would want any backstay tension in lighter air when you are looking for power (except you might want to take the slack out of the backstay to keep the mast tip from bouncing around in waves).

Once your crew is hiking and the boat is powered up and going fast, then you can think about adding backstay. Of course, the amount you need depends on wave state as well as wind velocity. In flat water you might start pulling the backstay quite a bit earlier than in chop (when you need more power).

When it gets really windy, then you need to pull the backstay very hard. This flattens the main, adds twist and thereby depowers the sail plan so you can sail the boat flatter with less windward helm.

However, if you bend the mast too much, you will flatten the sail beyond its designed sail shape. In that case you will likely see ugly overbend wrinkles and the leech will fall off to leeward, which is bad for speed and pointing. So normally pull the backstay only until you see a hint of overbend wrinkles.

If the backstay affected only the mainsail, then life would be easy, but that is not the case. When you pull the backstay, you also tighten the headstay, which flattens the jib and moves its draft aft. The trick is finding the backstay setting that optimizes the shape of both sails at the same time, and sometimes this means you must compromise.

In light air, for example, the mainsail likes enough mast bend to match its designed luff curve. But if you get this by pulling the backstay you will depower the jib too much. The solution is to 'pre-bend' the mast (with tuning) so you can keep a loose backstay and powerful jib.

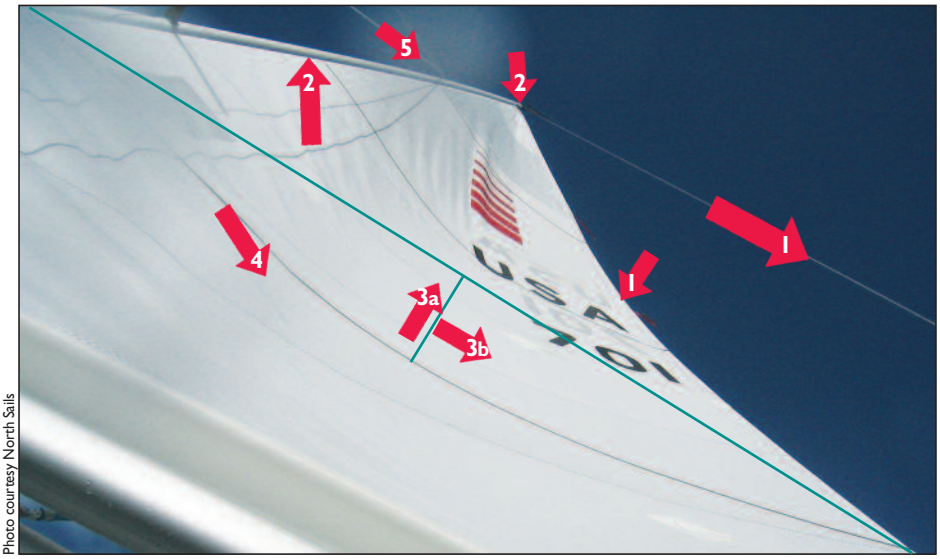


Photo courtesy North Sails

When you pull (or ease) the backstay, it affects the mast and sails in many ways:

1. Pulling the backstay shortens the distance between the top of the mast and the back of the boat. This reduces tension on the leech, so if you want to keep the same amount of twist you have to pull harder on the mainsheet. The opposite is true when you ease the backstay – the leech gets tighter so you have to ease mainsheet.

2. As the tip of the mast moves aft, the middle of the mast arcs forward. The entire spar acts like a lever with its fulcrum at the 'hounds' (the point where the forestay and shrouds attach to the mast).

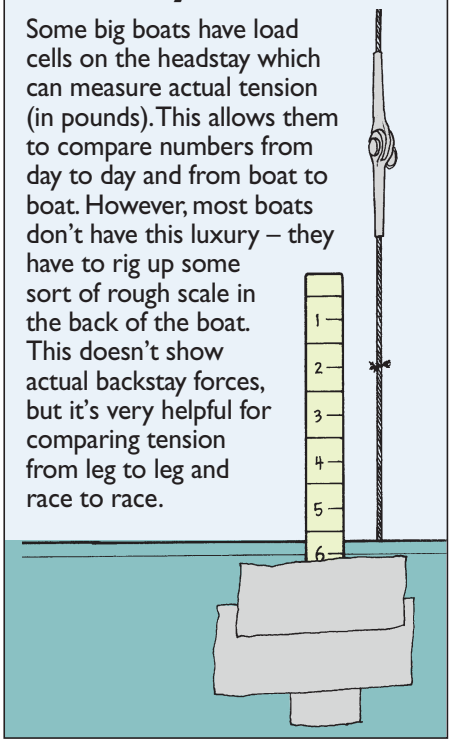
3. When the middle of the mast levers forward, it pulls cloth from the middle of the sail. This makes the main flatter overall (3a) and sucks the fullness out of the forward part of the sail, which moves the position of maximum draft farther aft (3b).

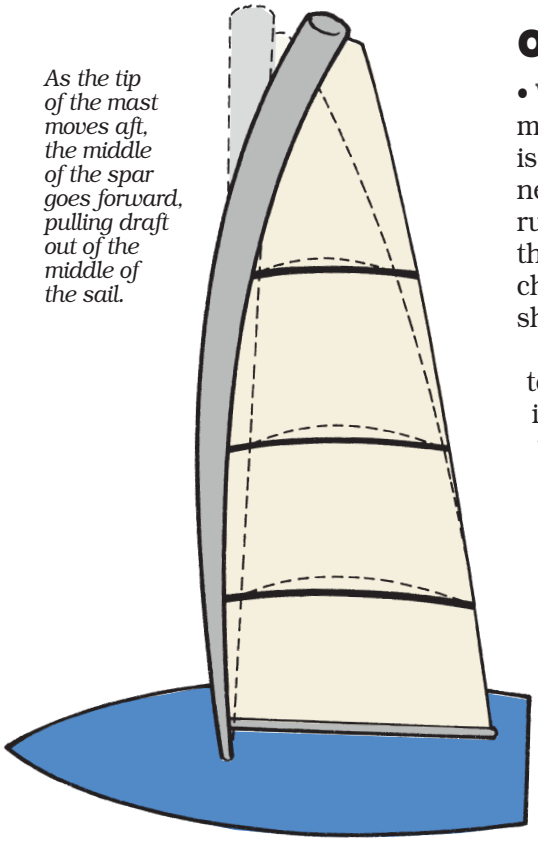
4. If the mast bends enough, it flattens the main past its designed sail shape. This results in the appearance of "overbend" or "inversion" wrinkles running from the middle of the mast toward the clew.

5. Because it pulls the top of the mast aft, the backstay also tensions the headstay. This reduces jib luff sag, making the jib flatter and more draft-aft overall.

Calibrate your backstay tension

Some big boats have load cells on the headstay which can measure actual tension (in pounds). This allows them to compare numbers from day to day and from boat to boat. However, most boats don't have this luxury – they have to rig up some sort of rough scale in the back of the boat. This doesn't show actual backstay forces, but it's very helpful for comparing tension from leg to leg and race to race.





As the tip of the mast moves aft, the middle of the spar goes forward, pulling draft out of the middle of the sail.

When you pull harder on the backstay, the mast bends, the sail flattens and the position of maximum draft in the sail moves aft toward the leech (solid draft stripes). When you ease the backstay, the mast gets straighter, the sail shape becomes fuller and the draft moves forward toward the mast (dotted stripes).

Other tips and notes

• **Watch for overbend wrinkles**. The backstay bends the mast and helps make the mainsail flatter when you are getting overpowered. However, it is very easy to pull the backstay too hard. One clear sign that you are near maximum backstay tension is the appearance of overbend wrinkles running from the clew toward the middle of the mast. If you have more than a hint of these wrinkles, ease the backstay slightly (or tension the checkstays if you have them) to straighten the mast and put a little more shape into the sail.

• **Ease backstay downwind.** When you're sailing on a run, it's not fast to pull the top of the mast aft. Ease the backstay until the mast is vertical in the boat or actually raked forward (but in windy conditions don't ease the backstay so much that the mast has reverse bend). On an overpowered reach, it's OK to keep the backstay on to depower the sailplan.

• **Adjust backstay, adjust mainsheet.** When you tension the backstay, it pulls the top of the mast aft. If you don't touch the mainsheet, the leech of the sail will twist off to leeward because the top of the mast is closer to the aft end of the boom. Therefore, whenever you adjust the backstay you should make a corresponding change in mainsheet. If you tighten the backstay, tighten the sheet. If you ease the backstay, ease the sheet or the leech will get too tight (because the tip of the mast moves farther away from the end of the boom).

• **Use the backstay to change gears.** When conditions change, don't forget the backstay. As you get a puff, pull on more backstay to flatten the main and reduce headstay sag (which flattens the jib). In a lull, ease the backstay to add power to the overall sailplan.

• **Don't get hung up.** On some boats, the backstay often gets caught on the mainsail leech or the top batten during tacks or jibes. You may be able to prevent this by using some sail repair tape (with lube spray) to smooth over the spot that catches. It also may help to keep the backstay slightly taut (rather than loose), or to ease the main out quickly (and then re-trim it) just after completing a tack.

Running backstays and checkstays

Some bigger boats have running backstays or checkstays in addition to a 'permanent' backstay (which goes to the top of the mast). Running backstays are used on fractionally-rigged boats where the forestay is attached below the top of the mast. In these rigs the permanent backstay cannot do an effective job of tensioning the headstay because it doesn't pull directly against the headstay. So the boat has running backstays (one on each side of the boat) that go to the 'hounds' and therefore exert much better leverage for tensioning the headstay.

Besides controlling headstay sag (and jib shape), running backstays bend the mast, flatten the mainsail and move the draft aft, and therefore require similar trimming adjustments as a normal backstay to keep the boat going fast.

Some fractionally rigged boats and masthead boats also have checkstays to help control mast bend and mainsail shape. Checkstays are wires (or low-stretch lines) that run on each side of the boat from the stern (often they're connected to the running backstays) to the middle of the mast.

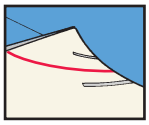
By tightening the checkstay, you can pull the middle of the mast aft, which keeps the mainsail from getting too flat. This is great because it means you can pull the backstay (or running backstay) tight enough to reduce headstay sag without giving up a good fast shape for the mainsail.

TEASER ANSWER (From page 1)

Since B established a leeward overlap from clear astern and within two of her hull lengths of A, rule 17 says B may not sail above her proper course while she remains overlapped and within two lengths of A. However, there are two times when the rule allows B to head up just after getting her overlap:

1) Heading up is B's proper course. Perhaps B was sailing below her proper course when she got her leeward overlap. Or maybe a shift in wind direction or pressure changed her proper course. In either case, B may head up to her proper course (as long as she gives A room to keep clear under rules 15 and 16), and A must keep clear (rule 11).

2) A second time B may head up is when as a result she "promptly sails astern of" A. This is OK even if B sails above her proper course to go behind A (*see the end of rule 17's first sentence*).



OUTHAUL

Fine-tune lower mainsail shape

The outhaul is used to adjust depth in the lower third of the main. The tighter you pull the outhaul, the flatter the sail becomes.

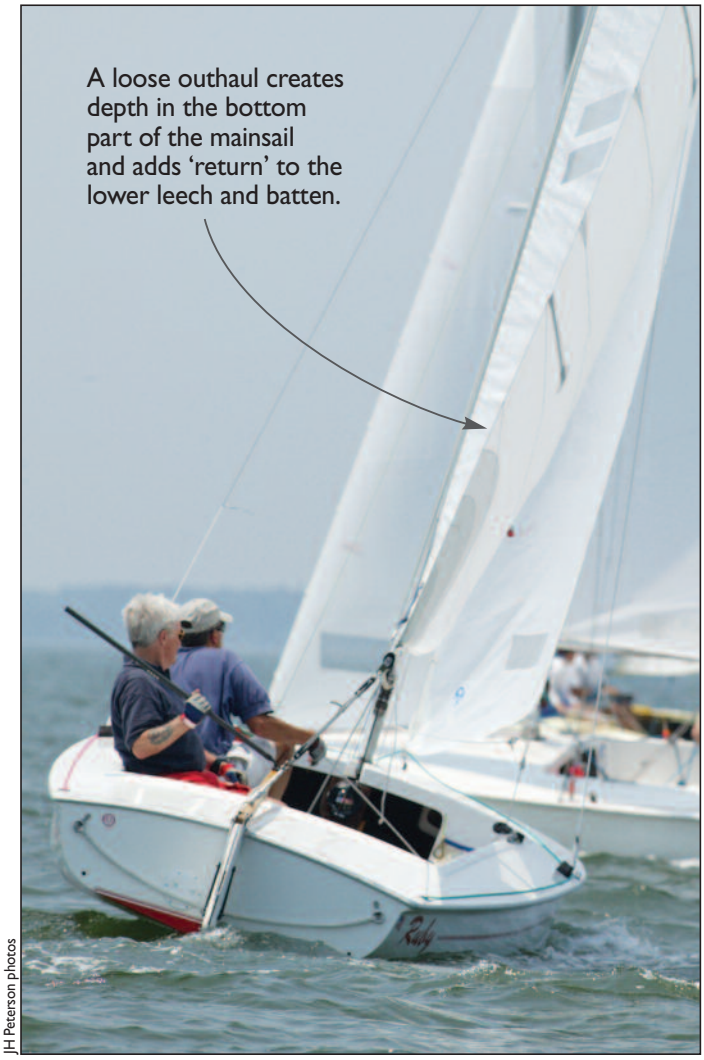
In theory, the optimal outhaul tension varies roughly in proportion to wind velocity. That is, the more wind you have the tighter the outhaul should be. In light air you are underpowered so you want a relatively eased outhaul to add depth, and therefore power, to the sail. In heavy air when you are overpowered, you want the bottom of the sail almost as flat as it can be to reduce heeling and windward helm. This requires a very tight outhaul.

Of course, the ideal outhaul setting is affected by waves as well as wind velocity. If you have more waves than wind (e.g. the breeze is dying), ease the outhaul slightly to add power. If you have more wind than waves (e.g. an offshore breeze), pull the outhaul tighter so you can trim harder and point higher.

Besides controlling fullness, the outhaul affects the attitude of the lower leech and the bottom batten. A loose outhaul means the leech will be fairly closed and the batten angled to windward. The easiest way to see this is by looking at the mainsail from astern (*left photo*). With a tight lower leech, you will have more windward helm and a greater risk that the sail may be overtrimmed and stalled.

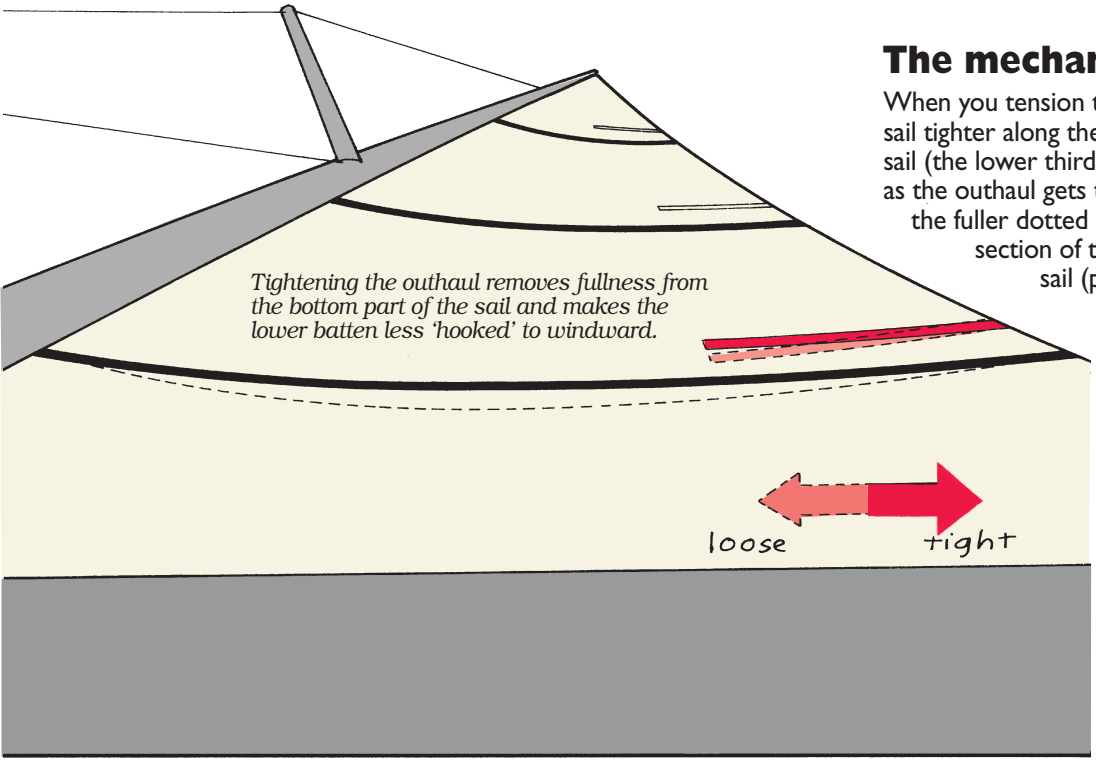
A tight outhaul (*right photo*) opens the lower leech and makes the bottom batten more nearly parallel to the boom. This sail shape produces less windward helm and is good in heavier wind when you are overpowered. In moderate wind, an open lower leech also allows you to trim the mainsheet harder without the risk of stalling the lower part of the sail before the upper.

In practice, a tighter outhaul often seems fast, even in lighter air. This opens the lower leech, which is helpful if you want to trim the mainsheet hard. Also, flattening the bottom of the sail opens up the slot between main and jib. One time when you might want a looser outhaul is in light air and chop when you need lots of power and you can't trim either sail very tight.



JH Peterson photos

With a loose outhaul (left), the bottom section of the main is relatively full and the lower leech is fairly 'closed.' You can see that the leech and lower batten are angled pretty far to windward. This is OK when you want power without trimming the mainsheet too tight. But in many cases, if you trim the sheet tight enough to reduce twist in the upper leech, the lower leech will be hooked too far to windward. One solution is to add outhaul tension (*see above*). This opens up the lower leech and allows you to trim the sheet harder. The goal is to have the upper and lower leeches arrive at a fast trim simultaneously – this will optimize speed and pointing.



The mechanics of 'hauling out'

When you tension the outhaul, it pulls the foot of the mainsail tighter along the boom, which makes the bottom of the sail (the lower third or so) flatter. This diagram shows that, as the outhaul gets tighter., the lower draft stripe goes from the fuller dotted line to the flatter solid line. The lower section of the main is usually the flattest part of any sail (partly because this is necessary to keep the slot between main and jib open), and a tight outhaul can make it almost board flat if necessary to depower.

Outhaul tension also affects the lower part of the mainsail leech and the angle of the bottom batten. When you tighten the outhaul and flatten the sail, this opens the lower leech and makes the batten more nearly parallel to the boom (and less angled to windward). As you ease the outhaul and make the sail fuller, you get more 'return' in the lower leech – it becomes more 'closed' or 'hooked,' and the batten angles to windward.

Other tips and notes

• **Calibrate outhaul tension.** There are two ways to quantify outhaul tension. The first is by measuring the distance from the middle of the foot to the boom. For example, the outhaul might be two inches from the boom in light air and chop, but only one inch in moderate air and flat water. This method allows you to compare outhaul tension from boat to boat.

A second approach is to put a number scale at the end of the boom (or near the cleat on the forward part of the boom) and look to see where a particular part of the outhaul shackle or the sail's clew intersects the scale. For example, you might go to 2 in light air and 5 in heavy air. This is a good way to compare your own settings, but it won't help with other boats.

• **Watch for the band.** Many boats have a measurement band (or stripe) near the end of the boom. If you have a band, no part of the mainsail can extend aft of the forward edge of that band.

• **Get full extension.** When it's windy, you need to get the bottom of the sail as flat as possible. On many boats, the outhaul system is rigged in a way that prevents you from tensioning the outhaul all the way to the black band (or, if there is no band, to the end of the boom). Make sure you can pull your outhaul very tight – sometimes the fix is as simple as using a more compact knot or a shorter shackle on the outhaul.

Outhaul on reaches and runs

Most sailors are taught to ease their outhaul after rounding the windward mark, but that is only partly correct. When you are sailing on a reach or on a hot angle on a run (because the wind is light), it's good to ease your outhaul a bit from your upwind setting. In both of these situations the main is normally eased only about half way to the shrouds – you still have attached flow over the sail so a little extra shape in the bottom of the main will give you more power.

However, there are many other times when you probably want to keep your outhaul tight for sailing downwind:

• When you are on a reach and you're overpowered, don't ease the outhaul. Keep the bottom of the sail flat and depowered as much as possible – this will help balance the helm and maintain control. The last thing you want to do is make the mainsail deeper and increase windward helm.

• When you are running downwind with the main out all the way (which is most of the time), keep the outhaul tight to maximize projected sail area to the wind. The sail is usually completely stalled at this angle, so adding more shape is not faster – if you ease the outhaul it just makes the sail smaller.

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PREPARATION

Relative or absolute reference marks?

If you want to be consistently fast from race to race and regatta to regatta, you must be able to reproduce fast sail trim. When your boat feels good and is performing well relative to other boats, pay attention to your sail control settings so you can reproduce these the next time you have similar conditions. It is absolutely key to put reference marks on all your control systems so you can quantify fast settings and find them again quickly. You can use either relative marks (that are comparable only to themselves) or 'absolute' marks (that are calibrated so they compare to other boats). Here is a look at each.

Relative reference marks

The purpose of using 'relative' reference marks is to compare your own sail trim settings from one leg or race to another. These are easy to set up because all you need is a clear mark on a sheet or control line, or a simple number scale alongside anything (the mainsail clew, for example) that is being adjusted.

Relative reference marks can be very helpful, but their value is limited because you can't compare your own settings to other boats in your class. Try to use 'absolute' marks if possible (*see right*) unless you're in one of the following situations:

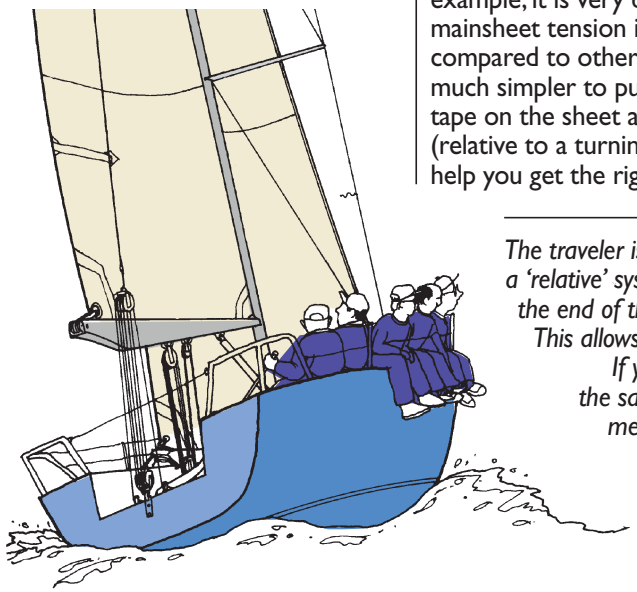
- There are no other boats exactly like yours; or
- A certain sail control cannot be calibrated in an absolute sense. For example, it is very difficult to measure mainsheet tension in a way that can be compared to other boats; instead, it's much simpler to put a bright piece of tape on the sheet and use its position (relative to a turning block, perhaps) to help you get the right trim consistently.

Absolute reference marks

The purpose of using 'absolute' reference marks is to compare your own sail trim settings to other boats like yours. These marks are especially useful for one-design boats where tuning numbers are expressed in absolute terms to make it easy for sailors to use them.

Absolute references are used all the time for tuning measurements (e.g. for mast rake, rig tension, spreader sweep, pre-bend), but they don't work for all sail control settings. For example, it's hard to compare vang tension from one boat to another, so that is one place where you need a relative mark.

One good thing about 'absolute' marks is that you can also use them as relative references. So whenever you add a reference mark on your boat, try to use an absolute scale that is comparable to other boats. For example, instead of just using a random number scale for the outhaul, create a scale on the end of the boom that is calibrated in standard units (e.g. inches or centimeters).



The traveler is a sail control where you can use either type of reference system. In a 'relative' system, you might put a zero in the middle of the traveler track, a 10 at the end of the track on each side, and then space the other numbers in between. This allows you to compare traveler settings from tack to tack and race to race. If you want to compare your settings to those of your friend (who has the same type of boat), you have to calibrate the track in standard units of measure. For example, you might mark off your traveler in inches (instead of random numbers). This 'absolute' method allows you to compare traveler settings after a race (assuming your friend uses the same system). For example, you might say, "Our traveler car position was usually 10 inches to windward of centerline."